US010044223B2

(12) **United States Patent**
Chang et al.

(10) **Patent No.: US 10,044,223 B2**
(45) **Date of Patent: Aug. 7, 2018**

(54) **GALVANIC ISOLATOR CIRCUIT**

(71) Applicant: **Industrial Technology Research Institute**, Hsinchu (TW)

(72) Inventors: **Yuan-Tai Chang**, New Taipei (TW); **Kai-Cheung Juang**, Hsinchu (TW)

(73) Assignee: **Industrial Technology Research Institute**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 118 days.

(21) Appl. No.: **15/047,641**

(22) Filed: **Feb. 19, 2016**

(65) **Prior Publication Data**

US 2017/0207655 A1 Jul. 20, 2017

(30) **Foreign Application Priority Data**

Jan. 19, 2016 (TW) .... 105101495 A

(51) **Int. Cl.**

H01F 27/42	(2006.01)
H01F 37/00	(2006.01)
H01F 38/00	(2006.01)
H02J 50/10	(2016.01)
H01F 38/14	(2006.01)

(52) **U.S. Cl.**

CPC ***H02J 50/10*** (2016.02); ***H01F 38/14*** (2013.01)

(58) **Field of Classification Search**

CPC H02J 50/10; H01F 38/14

USPC 307/104

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,801,883	A	1/1989	Muller et al.	
4,863,806	A	9/1989	Merrick et al.	
4,980,568	A	12/1990	Merrick et al.	
5,148,243	A	9/1992	Merrick et al.	
5,500,912	A	3/1996	Alonas et al.	
5,751,009	A	5/1998	Anderson et al.	
6,087,882	A *	7/2000	Chen	H04L 25/0266 327/333

(Continued)

FOREIGN PATENT DOCUMENTS

CN	200979983	11/2007
CN	102620031	8/2012

(Continued)

OTHER PUBLICATIONS

Kaeriyama et al., "A 2.5 kV Isolation 35 kV/us CMR 250 Mbps Digital Isolator in Standard CMOS With a Small Transformer Driving Technique," IEEE Journal of Solid-State Circuits, Feb. 2012, pp. 435-442.

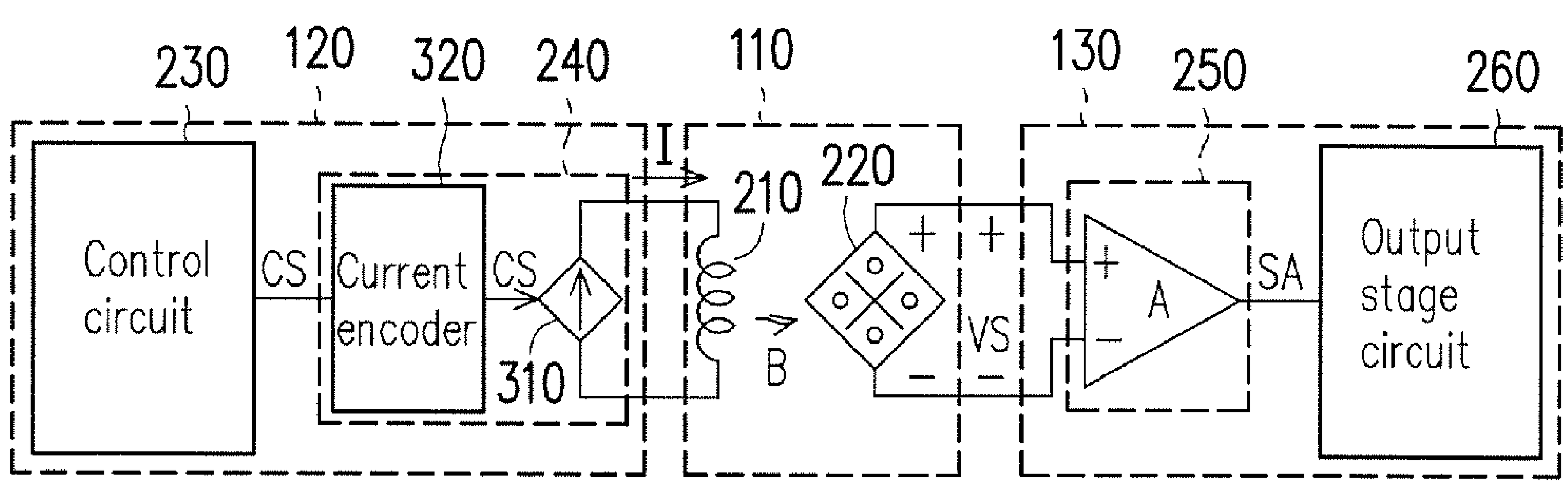
(Continued)

Primary Examiner — Lincoln Donovan
Assistant Examiner — Metasebia Retebo
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

An galvanic isolator circuit is provided. The electronic isolator circuit includes a coil and a magnetic field (MF) sensor. The coil is coupled to a first circuit. The MF sensor is coupled to a second circuit, and disposed corresponding to the coil. The first circuit transfers a MF signal to the MF sensor via the coil. The MF sensor transforms the MF signal into an output signal and provides the output signal to the second circuit. Accordingly, the galvanic isolator circuit is capable of realizing functions for galvanic isolating by utilizing the coil and the MF sensor.

16 Claims, 3 Drawing Sheets



100

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,545,059	B2 *	6/2009	Chen	H01F 17/0006 307/412
7,818,890	B2 *	10/2010	Duric	B82Y 25/00 324/209
7,920,010	B2	4/2011	Chen, Jr. et al.	
8,064,972	B2	11/2011	McLoone et al.	
8,076,793	B2	12/2011	Robbins	
8,169,108	B2	5/2012	Dupuis et al.	
8,385,043	B2	2/2013	Ng et al.	
8,390,093	B1	3/2013	Hopper et al.	
8,400,748	B2 *	3/2013	Yamamoto	H03F 3/181 361/143
8,451,032	B2	5/2013	Dong et al.	
8,592,944	B2	11/2013	Santangelo et al.	
8,736,343	B2	5/2014	Chen et al.	
8,878,591	B2	11/2014	Fang et al.	
9,019,057	B2	4/2015	Fouquet et al.	
2004/0021544	A1	2/2004	Wan	
2011/0199073	A1	8/2011	Myers et al.	
2014/0268917	A1 *	9/2014	Ma	H02M 3/33523 363/21.15
2014/0333295	A1	11/2014	Fernandez et al.	
2015/0022193	A1	1/2015	Burdette et al.	
2015/0041190	A1	2/2015	Bonifield et al.	
2015/0340872	A1	11/2015	Franzon et al.	
2017/0125343	A1 *	5/2017	Chang	H01F 27/2804

FOREIGN PATENT DOCUMENTS

CN	104269425	1/2015
TW	535000	6/2003
TW	201122753	7/2011
TW	201304401	1/2013
WO	2007029435	3/2007
WO	2010089974	8/2010
WO	2010095368	8/2010
WO	2010101222	9/2010
WO	2010137090	12/2010

OTHER PUBLICATIONS

Munzer et al., "Coreless transformer a new technology for half bridge driver IC's," International Exhibition and Conference for Power Electronics Intelligent Motion Power Quality, May 2003, pp. 1-4.

John R. Long, "Monolithic transformers for silicon RF IC design," IEEE Journal of Solid-State Circuits, Sep. 2000, pp. 1368-1382.

Kaeriyama et al., "A 2.5kV isolation 35kV/us CMR 250Mbps 0.13mA/Mbps digital isolator in standard CMOS with an on-chip small transformer," 2010 IEEE Symposium on VLSI Circuits (VLSIC), Jun. 16-18, 2010, pp. 197-198.

Mark Cantrell et al., "Recommendations for Control of Radiated Emissions with isoPower Devices," ADI: Application note AN-0971, retrieved on Feb. 15, 2016, pp. 1-20.

Silicon Labs, the datasheet of Si826x, retrieved on Feb. 15, 2016, pp. 1-40.

Avago Technologies, the datasheet of HCPL-316J, retrieved on Feb. 15, 2016, pp. 1-32.

M/A-COM Technology Solutions, Inc., the datasheet of MABA-010112-CT1A40, retrieved on Feb. 15, 2016, pp. 1-4.

* cited by examiner

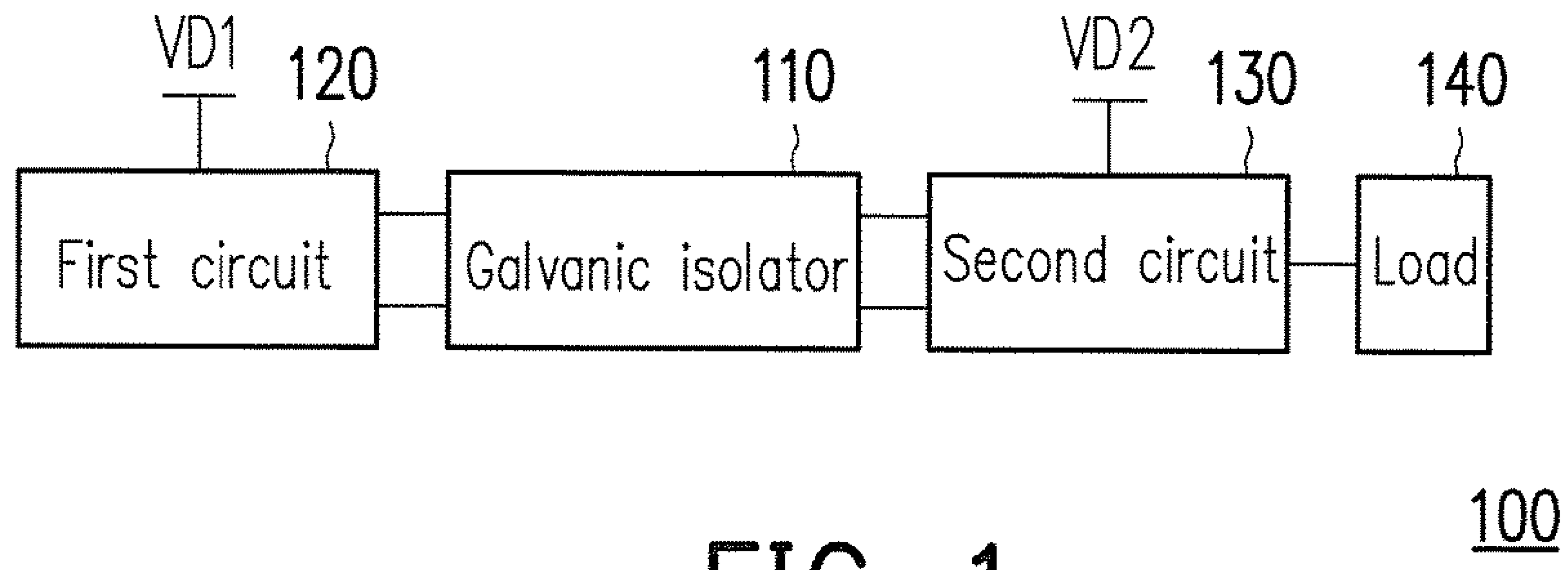


FIG. 1

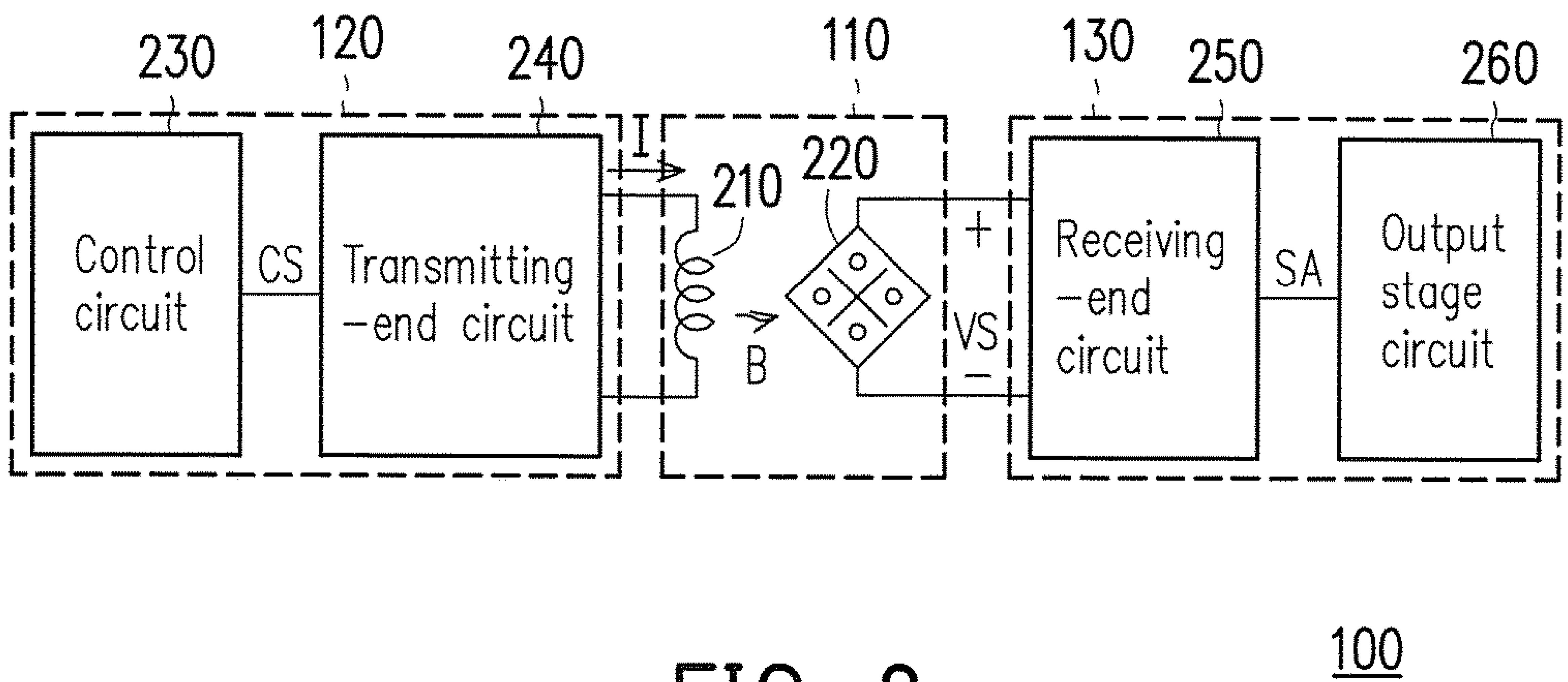


FIG. 2

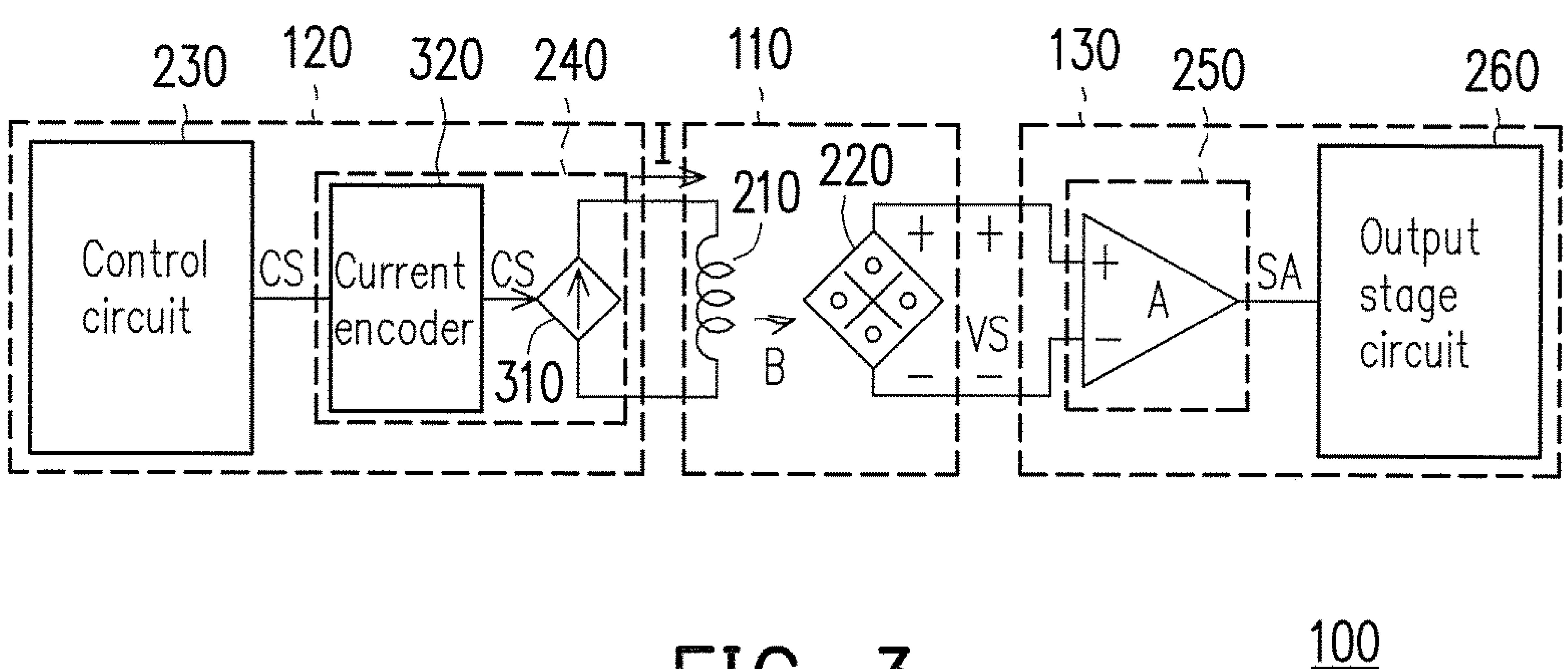
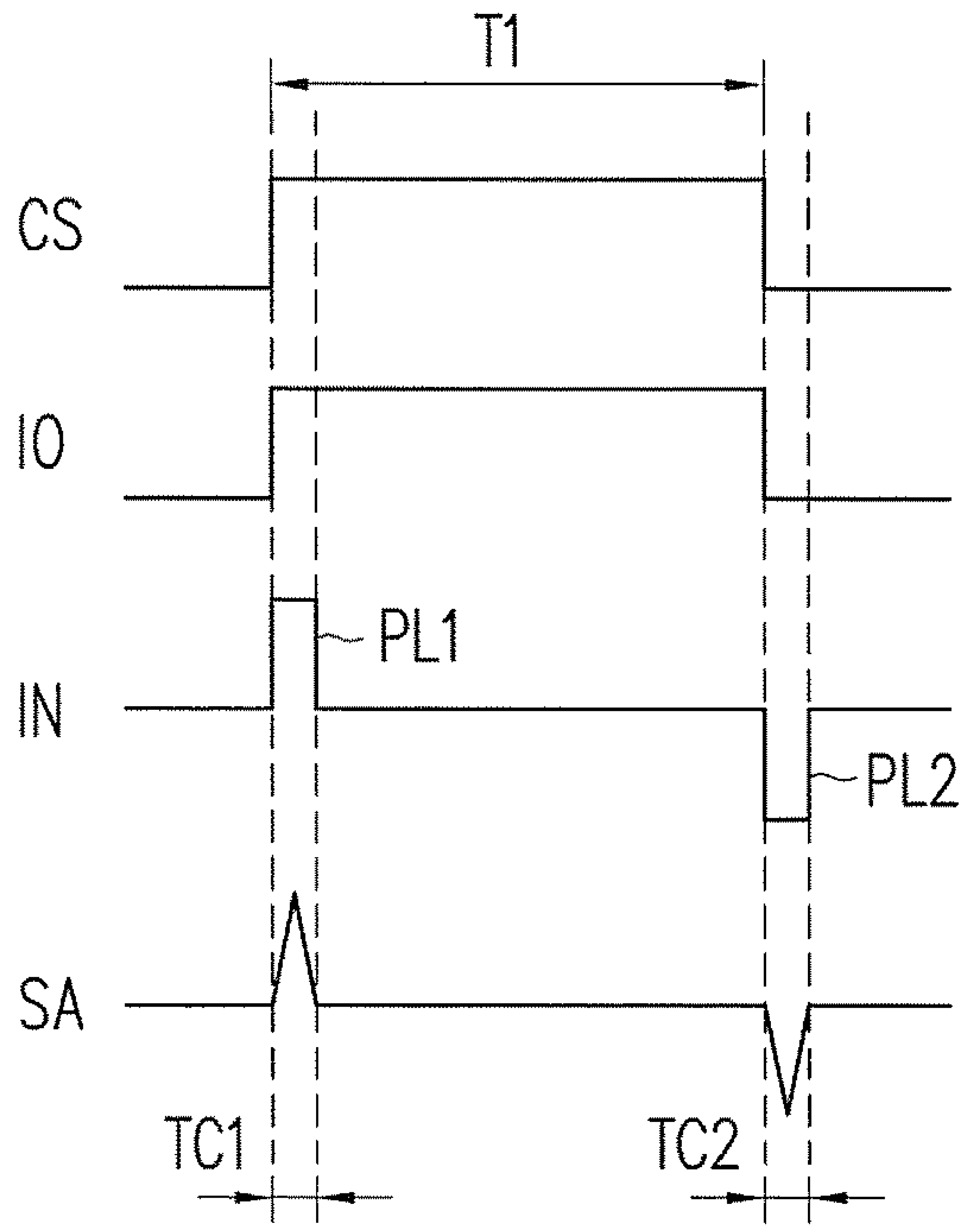
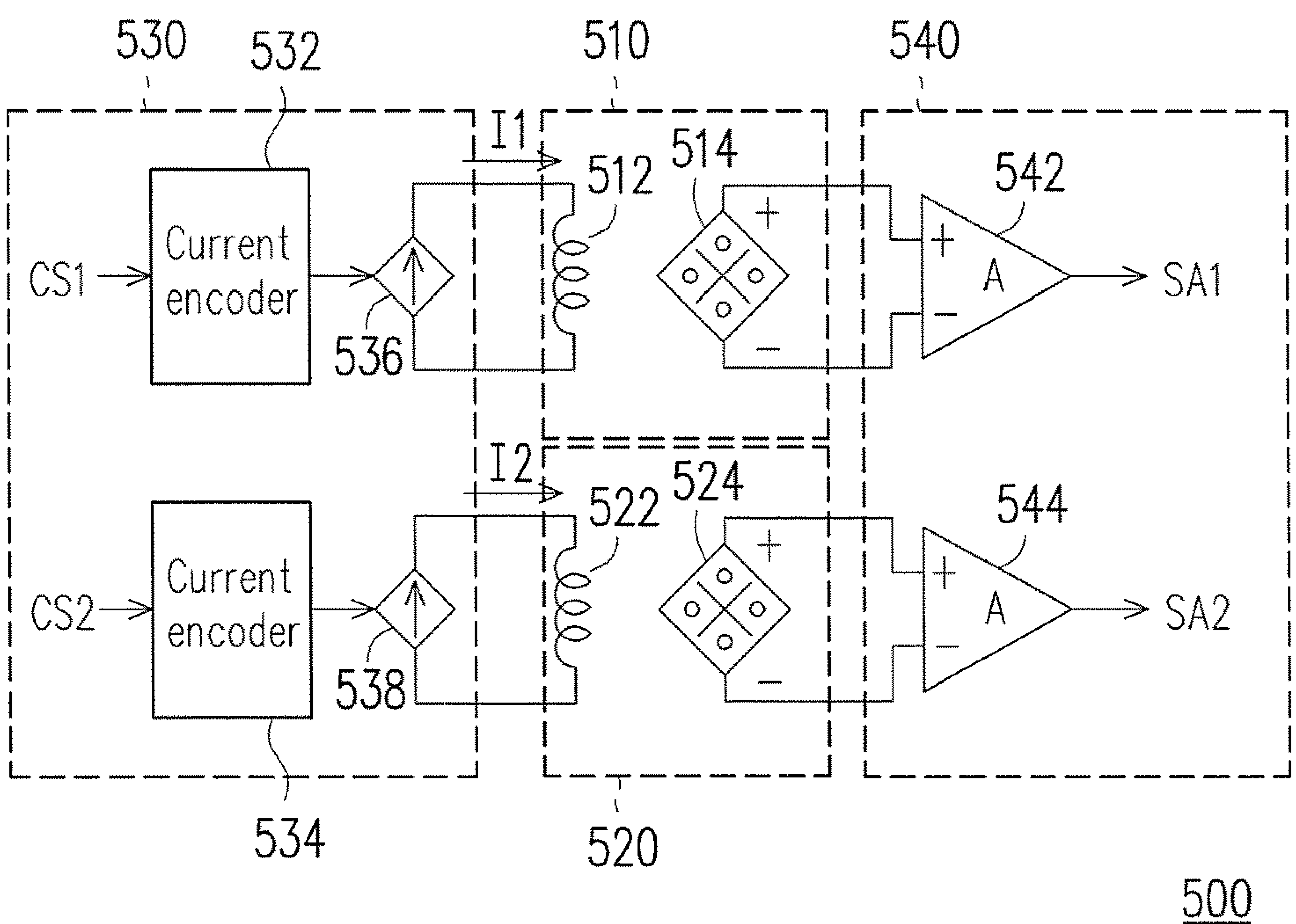


FIG. 3



T1
CS
IO
IN
PL1
PL2
SA
TC1
TC2

FIG. 4



530
532
510
540
I1
512
514
542
CS1
Current encoder
536
SA1
I2
522
524
544
CS2
Current encoder
538
SA2
534
520
500

FIG. 5

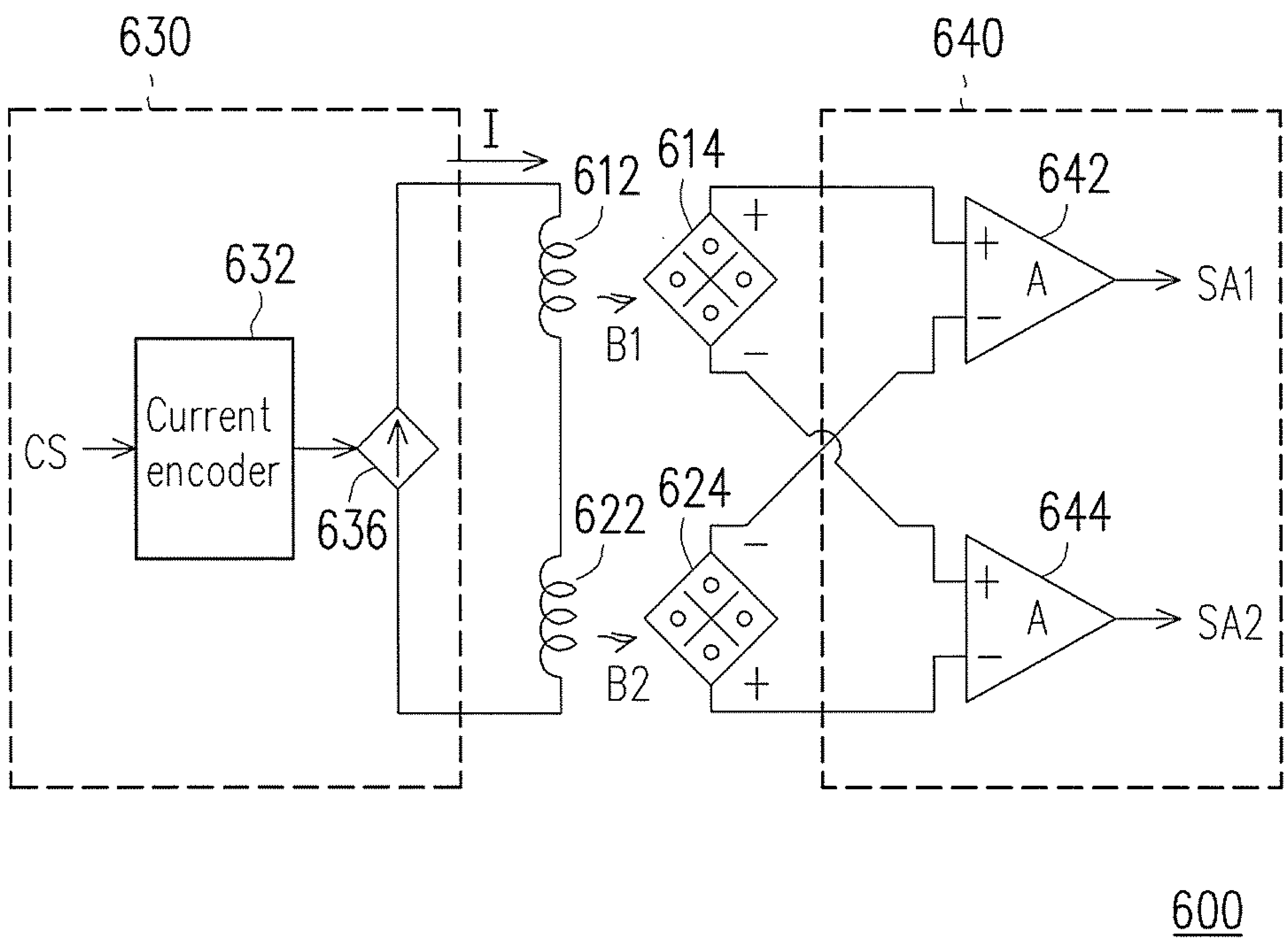

630
640
I
612
614
642
632
Current encoder
CS
SA1
B1
636
622
624
644
SA2
B2
A
600

FIG. 6

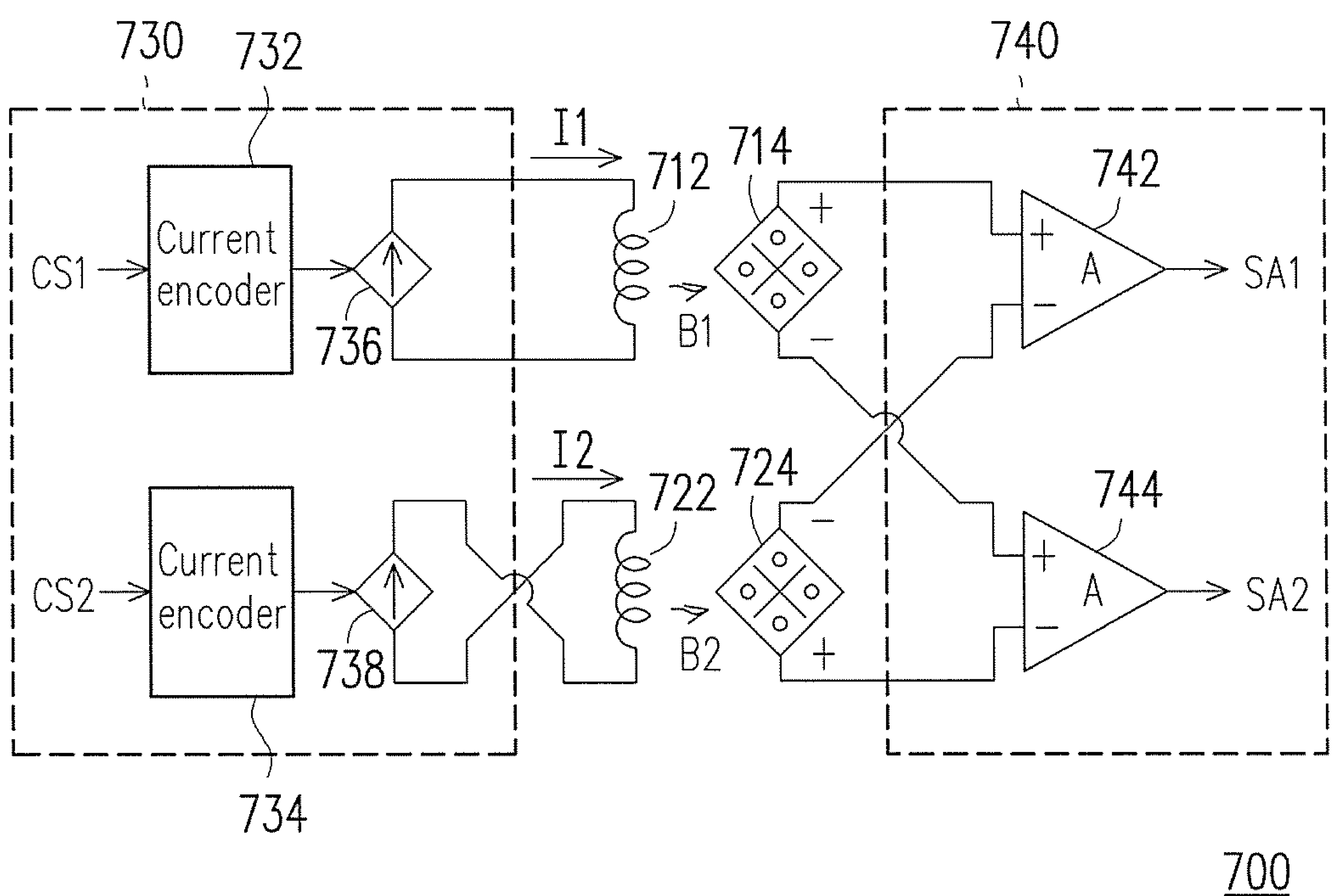

730
732
740
I1
712
714
742
Current encoder
CS1
SA1
B1
736
I2
722
724
744
Current encoder
CS2
SA2
B2
738
734
A
700

FIG. 7

GALVANIC ISOLATOR CIRCUIT

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefit of Taiwan application no. 105101495, filed on Jan. 19, 2016. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

TECHNICAL FIELD

The present disclosure relates to a galvanic isolator circuit.

BACKGROUND

In the field of signal transmission, it is often required to transmit a signal or energy from a circuit of one voltage domain to a circuit of another voltage domain, or from one medium to another medium. Due to the difference in voltage domain or medium, the signal may interfere with or cause breakdown in the peripheral circuits by the parasitic path during the transmission and result in damage. Considering the reliability of the circuits, galvanic isolators, signal isolators, couplers, or isolation barriers are usually adopted for transmitting signals between the circuits of different voltage domains, to protect the circuits.

Galvanic isolators are applicable to many fields of power supply circuits, such as power supply systems (e.g., power supplies, motor control systems, server power supply systems, and home appliances), illumination control systems (e.g., LED controllers), industrial motor systems (e.g., robotic arms and car motors), and so on. The aforementioned power supply circuit systems usually generate signals or commands through a control circuit, to control the output stage circuit and transfer energy to the load.

Currently, galvanic isolators are usually implemented by using optical couplers, capacitors, or transformers. In the case of using an optical coupler as the galvanic isolator, the manufacturing process of LED is not compatible with the transistor manufacturing process (e.g., CMOS manufacturing process) and LED has issues such as light decay and heat loss. Therefore, LED cannot be integrated into the chip and additional packaging is required. Nevertheless, if a transformer or capacitor, which may be integrated into the chip, is used as the galvanic isolator, transmission of high frequency signals may be needed in order to achieve efficient transmission. As a result, the circuit equipped with such galvanic isolator will require additional modulation and demodulation functions for signal transmission. Thus, how to implement a galvanic isolator that may lower power consumption and reduce signal distortion remains an issue that needs to be addressed.

SUMMARY

The present disclosure is directed a galvanic isolator circuit which utilizes a coil and a magnetic field sensor for realizing functions for galvanic isolating by magnetic coupling.

A galvanic isolator circuit according to one embodiment of the disclosure includes a coil and a magnetic field sensor. The coil is coupled to a first circuit. The magnetic field sensor is coupled to a second circuit, and the magnetic field sensor is disposed corresponding to the coil. The first circuit

transfers a magnetic field signal to the magnetic field sensor via the coil. The magnetic field sensor transforms the magnetic field signal into an output signal and provides the output signal to the second circuit.

A galvanic isolator circuit according to one embodiment of the disclosure includes a first coil, a second coil, a first magnetic field sensor and a second magnetic field sensor. The first coil and the second coil are coupled to a transmitting-end circuit. The first magnetic field sensor and the second magnetic field sensor are coupled to a first receiving-end circuit and a second receiving-end circuit respectively. The first magnetic field sensor is disposed corresponding to the first coil, and the second magnetic field sensor is disposed corresponding to the second coil. The transmitting-end circuit transfers a first magnetic field signal and a second magnetic field signal to the first magnetic field sensor and the second magnetic field sensor respectively via the first coil and the second coil. The first magnetic field sensor transforms the first magnetic field signal into a first output signal and provides the first output signal to the first receiving-end circuit. The second magnetic field sensor transforms the second magnetic field signal into a second output signal and provides the second output signal to the second receiving-end circuit.

Based on the above, the galvanic isolator circuit in the embodiments of the disclosure utilizes the coil and the magnetic field sensor to implement the functions of the galvanic isolator by magnetic coupling. The galvanic isolator according to the embodiments of the disclosure may be combined with chip manufacturing processes, and the transmitted signal may be a high frequency signal or a low frequency signal and do not need to be modulated or demodulated. Accordingly, the galvanic isolator according to the embodiments of the disclosure is capable of lowering power consumption, reducing signal distortion and lowering manufacturing process costs and packaging costs. Furthermore, the galvanic isolator may be manufactured and integrated into the chip by the semiconductor manufacturing process. On the other hand, the galvanic isolation is capable of realizing functions for galvanic isolating by utilizing two coils and two magnetic field sensors to eliminate the common mode noise and amplify the differential mode signal, to resist the noise interference.

To make the above features and advantages of the present disclosure more comprehensible, several embodiments accompanied with figures are described in detail as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure.

FIG. **1** is a schematic diagram illustrating a circuit adopting a galvanic isolator according to the first embodiment of the disclosure.

FIG. **2** is a functional block diagram illustrating the circuit adopting the galvanic isolator according to the first embodiment of the disclosure.

FIG. **3** is a detailed circuit diagram of the transmitting-end circuit and the receiving-end circuit in the circuit.

FIG. **4** is a tuning diagram of a control signal, an unencoded transmission current, an encoded transmission current and an output signal.

FIG. **5** is a functional block diagram illustrating a circuit adopting two galvanic isolators according to the second embodiment of the disclosure.

FIG. **6** is a schematic diagram illustrating a circuit adopting a galvanic isolator circuit according to the third embodiment of the disclosure.

FIG. **7** is a schematic diagram illustrating a circuit adopting a galvanic isolator circuit according to the fourth embodiment of the disclosure.

DETAILED DESCRIPTION

In the following detailed description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

FIG. **1** is a schematic diagram illustrating a circuit **100** adopting a galvanic isolator **110** according to the first embodiment of the disclosure. The circuit **100** mainly includes the galvanic isolator **110**, a first circuit **120** and a second circuit **130**. A power supply of the first circuit **120** is connected to a first voltage domain VD**1**, and a power supply of the second circuit **130** is connected to a second voltage domain VD**2**. In other words, the first circuit **120** belongs to the first voltage domain VD**1**, and the second circuit **130** belongs to the second voltage domain VD**2**. The circuit **100** may further include a load **140**. The load **140** is connected to an output of the second circuit **130**.

In the present embodiment, the first voltage domain VD**1** and the second voltage domain VD**2** may be different. In that case, it is required to use the galvanic isolator **110** to transfer signals and isolate the voltage domains. In the present embodiment, the circuit **100** is applicable to a power supply circuit system. Therefore, the second voltage domain VD**2** may be 20V to 35 kV depending on the power supply circuit system that is used. The first voltage domain VD**1** is a voltage range commonly used for the control circuit, such as 1.25V, 3.3V, 5V, and so on. In addition, according to different applications of the power supply circuit system, the load **140** may be a power supply, illumination equipment, a motor, a home appliance, a robotic arm, a car motor, and so on. Nevertheless, the embodiment of the disclosure is not limited to the aforementioned.

FIG. **2** is a functional block diagram illustrating the circuit **100** adopting the galvanic isolator **110** according to the first embodiment of the disclosure. Referring to FIG. **2**, the galvanic isolator **110** includes a coil **210** and a magnetic field sensor **220**. In the present embodiment, the magnetic field sensor **220** may be implemented by a Hall sensor (or called a Hall device). The first circuit **120** includes a control circuit **230** and a transmitting-end circuit **240**. The control circuit **230** may generate a control signal CS. In the present embodiment, the control signal CS is implemented by a pulse width modulation (PWM) signal, but the disclosure is not limited thereto. The transmitting-end circuit **240** is coupled to the coil **210**. The transmitting-end circuit **240** mainly receives the control signal CS, generates a transmission current I according to the control signal CS, and provides the transmission current I to the coil **210** to have the coil **210** generates a magnetic field signal B.

The second circuit **130** includes a receiving-end circuit **250** and an output stage circuit **260**. The magnetic field sensor **220** generates an output signal VS according to a magnitude of the magnetic field signal B. In the present embodiment, the magnetic field sensor **220** may be the Hall sensor. The receiving-end circuit **250** is configured to receive the output signal VS and process the output signal (e.g., amplifying signal, filtering signal, etc.). The output stage circuit **260** may determine whether to provide energy to the load **140** of FIG. **1** according to a processed output signal SA. In the present embodiment, the output stage circuit **260** may be a power output stage circuit.

FIG. **3** is a detailed circuit diagram of the transmitting-end circuit **240** and the receiving-end circuit **250** in the circuit **100**. In FIG. **3**, the coil **210**, the magnetic field sensor **220**, the control circuit **230** and the output stage circuit **260** are similar to those elements with the identical names in FIG. **2**. The transmitting-end circuit **240** includes a controlled current source **310** and a current encoder **320**. In the present embodiment of the disclosure, the current encoder **320** is configured to control the controlled current source **310**, and transforms the control signal CS into the transmission current I which causes the coil **210** to generate the magnetic field signal B. However, if the control signal CS (e.g., the PWM signal) is simply transformed into the transmission current I, the controlled current source **310** will continuously maintain the transmission current I during an enable period of the control signal CS to cause unnecessary waste of power.

FIG. **4** is a timing diagram of a control signal CS, an un-encoded transmission current IO, an encoded transmission current IN and an output signal SA. Referring to FIG. **3** and FIG. **4** together, when the control signal CS is at an enable period T**1**, the un-encoded transmission current IO maintaining its current amount during said enable period T**1** will lead to waste of power. For saving the waste of power, in the transmitting-end circuit **240** of the present embodiment of the disclosure, the current encoder **320** may generate a pulse portion (e.g., PL**1**, PL**2**) in the encoded transmission current IN by controlling the controlled current source **310** according to a potential transition portion (e.g., a period TC**1** in which the control signal CS changes from a disable state to an enable state and a period TC**2** in which the control signal CS changes from the enable state to the disable state) of the control signal CS. Accordingly, the output signal SA processed by the magnetic field sensor **220** and the receiving-end circuit **250** generates pulses in tip shape so that transition time points of the control signal CS may be learn. In other words, the current encoder **320** detects an edge portion of the control signal CS during the transition and generates the corresponding pulse portion (e.g., PL**1**, PL**2**) in the encoded transmission current IN when said edge portion is detected so the subsequent circuits (e.g., the output stage circuit **260**) may learn of the transition time points of the control signal CS in order to achieve the effectiveness of power saving.

Referring back to FIG. **3**, the receiving-end circuit **250** mainly includes an output amplifier **330**. The output amplifier **330** is coupled to two ends of the magnetic field sensor **220**. In other words, A non-inverting receiving node of the output amplifier **330** is coupled to a non-inverting output of the magnetic field sensor **220**, and an inverting receiving node of the output amplifier **330** is coupled to an inverting output of the magnetic field sensor **220**. Accordingly, the magnetic field sensor **220** may moderately amplify the output signal SA according to its built-in output gain (e.g., a built-in gain is A) to facilitate signal processing performed by the subsequent output stage circuit **260**. The receiving-end circuit **250** may also include a filter, a rectifier and so on, which are adjustable according to different applications and design requirements for the circuit.

The circuit **100** in the embodiments of the present disclosure may further adopt modulation and demodulation functions to transfer the control signal CS more smoothly. In FIG. **2** and FIG. **3**, the control circuit **230** in the circuit **120** may also include a modulator (not illustrated), and the output stage circuit **260** in the first circuit **120** may also include a demodulator (not illustrated) correspondingly. The modulator is configured to modulate the control signal CS. The first circuit **120** transfers the magnetic field signal B to the magnetic field sensor **220** via the coil **210** according to the modulated control signal CS. The demodulator is configured to demodulate the output signal SA generated by the magnetic field sensor **220**. However, in the present embodiment of the disclosure, a magnetic field induction between the coil **210** and the magnetic field sensor **220** is adopted for coupling. As such, because of less noise interference provided by the above method, it is relatively less required to protect the control signal CS during transmission by using the modulator and the demodulator.

In some embodiments, two galvanic isolators may be used to transfer signals in order to prevent the signal passed through one single galvanic isolator from losing or suffering noise interference. FIG. **5** is a functional block diagram illustrating a circuit **500** adopting two galvanic isolators **510** and **520** according to the second embodiment of the disclosure. The circuit **500** mainly includes the galvanic isolator **510** composed of a first coil **512** and a magnetic field sensor **514**, and the galvanic isolator **520** composed of a second coil **522** and a magnetic field sensor **524**.

In addition, the circuit **500** also includes a transmitting-end circuit **530** and a receiving-end circuit **540**. Because two galvanic isolators are used for transferring signals, the transmitting-end circuit **530** will include two current encoders **532** and **534** and two controlled current sources **536** and **538**. The current encoders **532** and **534** receive different control signals CS**1** and CS**2**, respectively, and control the controlled current sources **536** and **538** to generate transmission currents I**1** and I**2**, respectively. If the control signals CS**1** and CS**2** are identical, it is also possible that only one single current encoder is needed to simultaneously control the controlled current sources **536** and **538** in order to generate the transmission currents I**1** and I**2**. The receiving-end circuit **540** includes two output amplifiers **542** and **544**, which are used to receive and amplify signals from the magnetic field sensor **514** and the magnetic field sensor **524**, respectively, to generate output signals SA**1** and SA**2**.

Nonetheless, if the circuit **500** suffers interference from external magnetic field noises, the magnetic field sensor **514** and the magnetic field sensor **524** may also be influenced accordingly. As a result, a signal distortion may also occur on the output signals SA**1** and SA**2**. In order to reduce the noise interference while achieving the power saving requirement, a galvanic isolator circuit is additionally designed in the embodiments of the disclosure by adopting the concept of a common mode noise elimination and a differential mode signal amplification. FIG. **6** is a schematic diagram illustrating a galvanic isolator circuit **600** according to the third embodiment of the disclosure. In FIG. **6**, the galvanic isolator circuit **600** simply uses a controlled current source **636** and a current encoder **632** as a transmitting-end circuit **630**. A first end of the controlled current source **636** is coupled to a first end of a first coil **612**. A second end of the first coil **612** is coupled to a first end of a second coil **622**. A second end of the controlled current source **636** is coupled to a second end of the second coil **622**. Further, the present embodiment of the disclosure expects that two magnetic field signals B**1** and B**2** may include signal differential input functions. Therefore, a winding direction of the first coil **612** is designed to be different from a winding direction of the second coil **622** in the present embodiment of the disclosure. For example, when the winding direction of the first coil **612** is clockwise direction, the winding direction of the second coil **622** is changed to counter clockwise direction. Accordingly, when the current encoder **632** controls the controlled current source **636** to generate a transmission current I, the transmission current I will simultaneously flow through the first coil **612** and the second coil **614** and simultaneously generate the magnetic field signal B**1** and the magnetic field signal B**2** with different phases. As such, the galvanic isolator circuit **600** does not need to include two current encoders nor two controlled current sources, and costs and power consumption may both be saved.

On the other hand, the receiving-end circuit **640** of the galvanic isolator circuit **600** includes a first receiving-end circuit (e.g., a first output amplifier **642**) and a second receiving-end circuit (e.g., a second output amplifier **644**). Connection relationships among the first magnetic field sensor **614**, the second magnetic field sensor **624**, the first output amplifier **642** and the second output amplifier **644** are specially designed in the present embodiment of the disclosure, a common mode noise may be eliminated and an amplitude of a differential mode signal may be amplified. Specifically, a non-inverting receiving node of the first output amplifier **642** is coupled to a non-inverting output of the first magnetic field sensor **614** and an inverting receiving node of the first output amplifier **642** is coupled to an inverting output of the second magnetic field sensor **624**. On the other hand, a non-inverting receiving node of the second output amplifier **644** is coupled to an inverting output of the first magnetic field sensor **614** and an inverting receiving node of the second output amplifier **644** is coupled to a non-inverting output of the second magnetic field sensor **624**. Accordingly, because the magnetic field signals B**1** and B**2** have mutually inverse phases, the control signals contained in the magnetic field signals B**1** and B**2** may be amplified through computations of the output amplifiers **642** and **644**. In contrast, when the interference from the magnetic field noises occurs, because the first magnetic field sensor **614** and the second magnetic field sensor **624** may simultaneously detect the magnetic field noises, the common mode noise may be eliminated the computations of the output amplifiers **642** and **644**.

In some embodiments, the winding direction of the first coil **612** may also be designed to be identical to the winding direction of the second coil **622** as long as a method of connecting the magnetic field sensors with the rear stage amplifiers is slightly adjusted when designing the receiving-end circuit **640** so that the receiving-end circuit **640** may provide the signal differential input functions at the rear stage amplifiers.

FIG. **7** is a schematic diagram illustrating a galvanic isolator circuit **700** according to the fourth embodiment of the disclosure. The galvanic isolator circuit **700** includes a first coil **712**, a second coil **722**, a first magnetic field sensor **714**, a second magnetic field sensor **724**, a transmitting-end circuit **730**, and a receiving-end circuit **740**. The receiving-end circuit **740** and the output amplifiers **742** and **744** in FIG. **7** are similar to the receiving-end circuit **640** and the output amplifiers **642** and **644** in FIG. **6**. The difference between FIG. **6** and FIG. **7** is that, the transmitting-end circuit **730** in FIG. **7** mainly includes two current encoders **732** and **734** and two controlled current sources **736** and **738**. The controlled current sources **736** and **738** are coupled to the first coil **712** and the second coil **722**, respectively. A winding direction of the first coil **712** is identical to a winding direction of the second coil **722** (e.g., both of which winded in clockwise direction or winded in counter clockwise direction). Specifically, a non-inverting transmitting node of the controlled current source **736** is connected to a first end of the first coil **712**, and an inverting transmitting node of the controlled current source **736** is connected to a second end of the first coil **712**. In contrast, a non-inverting transmitting node of the controlled current source **738** is connected to a second end of the second coil **722**, and an inverting transmitting node of the controlled current source **738** is connected to a first end of the second coil **722**. Accordingly, a first transmission current I**1** generated by the controlled current source **736** flows in from the first end of the first coil **712**, and a second transmission current I**2** generated by the controlled current source **738** flows in from the second end of the second coil **722**. Accordingly, the first coil **712** and the second coil **722** may generate magnetic field signals B**1** and B**2** having mutually inverse phases.

In summary, the galvanic isolator circuit in the embodiments of the disclosure utilizes the coil and the magnetic field sensor (e.g., the Hall sensor) to implement the functions of the galvanic isolator by magnetic coupling. The galvanic isolator in the embodiments of the disclosure may be combined with a chip manufacturing process, and the transmitted signal may be a high frequency signal or a low frequency signal and do not need to be modulated or demodulated. Accordingly, the galvanic isolator in the embodiments of the disclosure is capable of lowering power consumption, reducing signal distortion and lowering manufacturing process costs and packaging costs. Furthermore, the galvanic isolator may be manufactured and integrated into the chip by the semiconductor manufacturing process. On the other hand, the galvanic isolation is capable of realizing functions for galvanic isolating by utilizing two coils and two magnetic field sensors to eliminate the common mode noise and amplify the differential mode signal, to resist the noise interference.

Although the present disclosure has been described with reference to the above embodiments, it will be apparent to one of ordinary skill in the art that modifications to the described embodiments may be made without departing from the spirit of the disclosure. Accordingly, the scope of the disclosure will be defined by the attached claims and not by the above detailed descriptions.

What is claimed is:

1. A galvanic isolator circuit, comprising:

a coil, coupled to a first circuit; and

a magnetic field sensor, coupled to a second circuit, and disposed corresponding to the coil,

wherein the first circuit transfers a magnetic field signal to the magnetic field sensor via the coil, and the magnetic field sensor transforms the magnetic field signal into an output signal and provides the output signal to the second circuit,

the first circuit comprises a control circuit, generating a control signal; and

a transmitting-end circuit, coupled to the coil, receiving the control signal, generating a transmission current according to the control signal, and providing the transmission current to the coil to have the coil generates the magnetic field signal,

wherein the transmitting-end circuit comprises a controlled current source; and a current encoder, controlling the controlled current source,

wherein the current encoder generates a pulse portion in the transmission current by the controlled current source according to a potential transition portion of the control signal.

2. The galvanic isolator circuit of claim **1**, wherein the second circuit comprises:

a receiving-end circuit, receiving the output signal; and

an output stage circuit, coupled to the receiving-end circuit, and determining whether to provide energy to a load according to the output signal.

3. The galvanic isolator circuit of claim **2**, wherein the receiving-end circuit comprises:

an output amplifier, coupled to two ends of the magnetic field sensor, to amplify the output signal according to an output gain.

4. The galvanic isolator circuit of claim **1**, wherein the first circuit belongs to a first voltage domain, and the second circuit belongs to a second voltage domain different from the first voltage domain.

5. The galvanic isolator circuit of claim **1**, wherein the magnetic field sensor is a Hall sensor.

6. The galvanic isolator circuit of claim **1**, wherein the first circuit comprises:

a modulator, configured to modulate a control signal, wherein the first circuit transfers the magnetic field signal to the magnetic field sensor via the coil according to the modulated control signal,

wherein the second circuit comprises:

a demodulator, configured to demodulate the output signal generated by the magnetic field sensor.

7. A galvanic isolator circuit, comprising:

a first coil and a second coil, coupled to a transmitting-end circuit; and

a first magnetic field sensor and a second magnetic field sensor, coupled to a first receiving-end circuit and a second receiving-end circuit respectively,

wherein the first magnetic field sensor is disposed corresponding to the first coil, and the second magnetic field sensor is disposed corresponding to the second coil,

wherein the transmitting-end circuit transfers a first magnetic field signal and a second magnetic field signal to the first magnetic field sensor and the second magnetic field sensor respectively via the first coil and the second coil,

wherein the first magnetic field sensor transforms the first magnetic field signal into a first output signal and provides the first output signal to the first receiving-end circuit, and the second magnetic field sensor transforms the second magnetic field signal into a second output signal and provides the second output signal to the second receiving-end circuit,

wherein the transmitting-end circuit comprises a controlled current source having a first end coupled to a first end of the first coil, a second end of the first coil coupled to a first end of the second coil, and a second end of the controlled current source coupled to a second end of the second coil, wherein a winding direction of the first coil is different from a winding direction of the second coil,

wherein the controlled current source generates a transmission current which simultaneously flows through the first coil and the second coil,

the transmitting-end circuit further comprises a current encoder, controlling the controlled current source, wherein the current encoder generates a pulse portion in the transmission current by the controlled current source according to a potential transition portion of a control signal.

8. The galvanic isolator circuit of claim **7**, wherein the first magnetic field sensor and the second magnetic field sensor is a Hall sensor.

9. The galvanic isolator circuit of claim **7**, wherein the first receiving-end circuit is a first output amplifier, and the second receiving-end circuit is a second output amplifier.

10. The galvanic isolator circuit of claim **7**, wherein the transmitting-end circuit comprises:

a first controlled current source, coupled to the first coil, and generating a first transmission current; and

a second controlled current source, coupled to the second coil, and generating a second transmission current,

wherein a winding direction of the first coil is identical to a winding direction of the second coil, wherein the first transmission current flows in from a first end of the first coil, and the second transmission current flows in from a second end of the second coil.

11. The galvanic isolator circuit of claim **10**, wherein the transmitting-end circuit further comprises:

a current encoder, controlling the controlled current source,

wherein the current encoder generates a pulse portion in the transmission current by the controlled current source according to a potential transition portion of a control signal.

12. The galvanic isolator circuit of claim **10**, wherein the first receiving-end circuit is a first output amplifier, and the second receiving-end circuit is a second output amplifier.

13. The galvanic isolator circuit of claim **12**, wherein the first output amplifier has a non-inverting receiving node coupled to a non-inverting output of the first magnetic field sensor and an inverting receiving node coupled to an inverting output of the second magnetic field sensor, and the second output amplifier has a non-inverting receiving node coupled to an inverting output of the first magnetic field sensor and an inverting receiving node coupled to a non-inverting output of the second magnetic field sensor.

14. The galvanic isolator circuit of claim **12**, wherein the first output amplifier has a non-inverting receiving node coupled to a non-inverting output of the first magnetic field sensor and an inverting receiving node coupled to an inverting output of the first magnetic field sensor, and

the second output amplifier has a non-inverting receiving node coupled to a non-inverting output of the second magnetic field sensor and an inverting receiving node coupled to an inverting output of the second magnetic field sensor.

15. A galvanic isolator circuit, comprising:

a first coil and a second coil, coupled to a transmitting-end circuit; and

a first magnetic field sensor and a second magnetic field sensor, coupled to a first receiving-end circuit and a second receiving-end circuit respectively,

wherein the first magnetic field sensor is disposed corresponding to the first coil, and the second magnetic field sensor is disposed corresponding to the second coil,

wherein the transmitting-end circuit transfers a first magnetic field signal and a second magnetic field signal to the first magnetic field sensor and the second magnetic field sensor respectively via the first coil and the second coil,

wherein the first magnetic field sensor transforms the first magnetic field signal into a first output signal and provides the first output signal to the first receiving-end circuit, and the second magnetic field sensor transforms the second magnetic field signal into a second output signal and provides the second output signal to the second receiving-end circuit,

wherein the transmitting-end circuit comprises a controlled current source having a first end coupled to a first end of the first coil, a second end of the first coil coupled to a first end of the second coil, and a second end of the controlled current source coupled to a second end of the second coil, wherein a winding direction of the first coil is different from a winding direction of the second coil,

wherein the controlled current source generates a transmission current which simultaneously flows through the first coil and the second coil,

the transmitting-end circuit further comprises a current encoder, controlling the controlled current source,

wherein the current encoder generates a pulse portion in the transmission current by the controlled current source according to a potential transition portion of a control signal,

wherein the first receiving-end circuit is a first output amplifier, and the second receiving-end circuit is a second output amplifier,

wherein the first output amplifier has a non-inverting receiving node coupled to a non-inverting output of the first magnetic field sensor and an inverting receiving node coupled to an inverting output of the second magnetic field sensor, and the second output amplifier has a non-inverting receiving node coupled to an inverting output of the first magnetic field sensor and an inverting receiving node coupled to a non-inverting output of the second magnetic field sensor.

16. A galvanic isolator circuit, comprising:

a first coil and a second coil, coupled to a transmitting-end circuit; and

a first magnetic field sensor and a second magnetic field sensor, coupled to a first receiving-end circuit and a second receiving-end circuit respectively,

wherein the first magnetic field sensor is disposed corresponding to the first coil, and the second magnetic field sensor is disposed corresponding to the second coil,

wherein the transmitting-end circuit transfers a first magnetic field signal and a second magnetic field signal to the first magnetic field sensor and the second magnetic field sensor respectively via the first coil and the second coil,

wherein the first magnetic field sensor transforms the first magnetic field signal into a first output signal and provides the first output signal to the first receiving-end circuit, and the second magnetic field sensor transforms the second magnetic field signal into a second output signal and provides the second output signal to the second receiving-end circuit,

wherein the transmitting-end circuit comprises a controlled current source having a first end coupled to a first end of the first coil, a second end of the first coil coupled to a first end of the second coil, and a second end of the controlled current source coupled to a second end of the second coil, wherein a winding direction of the first coil is different from a winding direction of the second coil,

wherein the controlled current source generates a transmission current which simultaneously flows through the first coil and the second coil, the transmitting-end circuit further comprises a current encoder, controlling the controlled current source,

wherein the current encoder generates a pulse portion in the transmission current by the controlled current source according to a potential transition portion of a control signal,

wherein the first receiving-end circuit is a first output amplifier, and the second receiving-end circuit is a second output amplifier,

wherein the first output amplifier has a non-inverting receiving node coupled to a non-inverting output of the first magnetic field sensor and an inverting receiving node coupled to an inverting output of the first magnetic field sensor, and

the second output amplifier has a non-inverting receiving node coupled to a non-inverting output of the second magnetic field sensor and an inverting receiving node coupled to an inverting output of the second magnetic field sensor.

* * * * *